A METHOD OF RECORDING EYE-MOVEMENTS.

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Many problems suggest themselves to the psychologist whose solution would be greatly furthered by an accurate method of recording the movements of the eye. One such problem in particular has aroused my interest, namely, the relation of eye-movements and eye-strain to our spatial judgments, and the bearing of this relation on the explanation of various geometrical optical illusions. While I cannot claim to have completely solved the problem of obtaining an accurate record of the movements made by the eye under such circumstances, I nevertheless have succeeded in reproducing them with a certain degree of accuracy; and by publishing my method in spite of its crudeness in certain respects, I hope to be of service to others who may be engaged on similar problems, and to receive suggestions for its further perfection.

After considering and testing numerous possibilities, I was forced to the conclusion that only by firmly attaching some solid object to the surface of the eye or to the eye-muscles, as a support to a mirror or to a thread for moving levers, could my object be obtained. I am indebted to Dr. Lough, my assistant last year in the laboratory at Harvard, for the suggestion that plaster-of-Paris will attach itself firmly and immovably to any moist surface. Acting on this suggestion, I made a few plaster casts over the cornea of an artificial eye. I thus produced a smooth concave surface that would fit fairly well the curvature of the cornea of a natural eye. This I trimmed with a knife to the diameter of the cornea, and to a thickness that would make it as light as possible while retaining the requisite firmness. Then I made the eyeball anæsthetic by applying two or three drops of a two to three per cent. solution of cocaine, and on fitting the cast over the cornea found that it held there perfectly, without pain or discomfort.

The problem of obtaining a firm support was thus solved. How to use it for obtaining a record of the eye-movements was yet a question. My first attempt was to fasten to the outer surface of the plaster cast a small concave mirror of known focus, and to reflect from it a strong ray of light onto a photographic plate. This reflected ray reproduced accurately and magnified all the movements of the eye. I found difficulty, however, in

obtaining a record of its path on the sensitive plate, and was compelled to abandon the attempt. This difficulty arose partially from the rapidity with which the spot of light moved across the plate, but partly also no doubt from my own unfamiliarity with the dispositions of apparatus necessary for obtaining a sharply defined image of the light-streak under such conditions. It seems to me probable that this photographic method is feasible, and I hope that this account may come to the notice of some one who can give me directions for making it successful.

I finally adopted the method of casting within the plaster a thin wire ring, from one side of whose circumference a branch projected to the outside. It was then possible to make a hole through the center of the cast, of about the size of the pupil. The wire ring surrounded this hole, imbedded within the plaster, and to its projection, situated just to one side of the opening, it was easy to attach a light thread leading to a recording lever. On the side of the lever opposite to the attachment of the thread I fastened a thin elastic fibre, and thus the lever moved back and forth in correspondence with the horizontal movements of the eye, and recorded them on the smoked surface of a kymograph cylinder. By running the thread over a pulley, it was similarly possible to record the vertical movements. Slow movements could thus be recorded with great accuracy. But in the case of the more natural rapid movements, the tendency of the lever and elastic fibre to continue vibratory movements of their own after those of the eye had ceased led to some results difficult to interpret. The periodicity of these vibrations gave me sometimes a valuable method of determining the time-relations of the eye-movements under various conditions, but prevented an absolutely accurate determination of the exact form of the movements. The method therefore still remains crude. I have, however, by its use satisfied myself that spatial judgments are closely dependent on eye-movements and eye-positions, and that many geometrical optical illusions can be proved to owe their explanation to this fact. I have also discovered, I think, a new factor of influence in these illusions, — namely, the fact that the actual point of fixation of the eye is not always the one intended and thought to be fixated. If, for instance, when the endeavor is made to fixate the point of an arrow-head, the actual point of fixation falls within the angle, as my results seem to establish, then in the Müller-Lyer illusion the length of eye-movement is actually less in the case of the diagram that appears shorter. A fuller account of the results that lead me to these conclusions I must however reserve until an improvement in the method and further opportunity for research permit of their verification.

A few further details will be of value to those who may wish

to adopt and perfect this method. The eye should first be cocainized as above indicated. Then the lids should be propped apart by some form of eye-lid fastener, of which the best is probably that in form of a wide-opening spring with tortoise-shell grooves for the lids. The plaster cast may then be applied, with its opening directly over the pupil, and it will at once adhere firmly. If the amount of cocaine used has not been sufficient to interfere with accommodation, it will then be possible to see with the harnessed eye almost if not quite as well as with the other. The plaster will not detach itself until it becomes thoroughly soaked with tears. I have taken records for over an hour without inconvenience from its application or from the propping open of the lids. If it is desired to obtain release before it detaches itself, it cannot be pulled off without injury to the eye, but a few drops of water applied within its opening and to the eye around it will cause it to float off at once.

As to whether there is any danger to the eye to be feared from using it in this manner, I cannot say with assurance. I have myself always suffered a little temporary inconvenience due to the strain on the eye-muscles, to the affecting of the accommodation by the cocaine, and to the fact that a cast over an artificial eye never corresponds exactly to the curvature of one's own cornea, and the latter probably alters itself during the experiment to fit the cast. I have also found it necessary to allow a considerable interval to elapse between experiments, — usually a week. The unplesant effects have always soon passed, and now, a full year since my last experiments, I can detect no ill effect.